DOE/GO-102001-1165
NREL/BK-710-29267
May 2001

7.1.2 Structural Building Components

Nearly all large buildings are constructed of steel and concrete. In smaller buildings, masonry and wood are also common as structural components. Each of these materials has its own environmental profile with distinct opportunities for environmental improvements, both in terms of how the materials are specified and how they are used in the design.

Because structure plays a critical role in a building, the conventional performance parameters of function and durability are particularly important from an environmental perspective. Of all building components, structural elements are the most difficult to repair or replace, so if they are not built for longevity, the entire building may need to be prematurely replaced, causing extra environmental impacts. As a result, choosing structural components for a green building requires a careful assessment of both function and materials.

Opportunities

Structural components require more material than any other element in most buildings. Because they are used in such quantity, the environmental burdens associated with these materials are magnified. Conversely, opportunities to benefit from green strategies are also significant. Choices regarding structural materials are generally limited to new construction, and the ramifications of those choices will extend through the life of the building.

In terms of integration with general green design strategies, two important considerations affect the selection and design of structural components:

- Structural materials may provide finished surfaces that can remain exposed either on the interior or exterior of the building. This approach can save money and reduce environmental burdens by leaving off entire layers of finish materials, each with its own maintenance and replacement requirements.
- Structural components should be designed for adaptability to changing demands on the space, ranging from minor modifications to a complete change in function. For example, large spaces with high ceilings can be designed to accommodate the future addition of an intermediate story if the space were to be converted into smaller offices or dwelling units.

Technical Information

Comparing the environmental impacts of different structural systems requires the balancing of many variables, including life-cycle impacts of the materials (see *Section 7.1 – Material Selection*), clear spans and structural loads, durability, and impact on the thermal performance of the building envelope. Each of the four common structural materials—steel, concrete, masonry, and wood—is appropriate for certain applications. Of the four, wood typically uses the least energy, causes the least pollution from manufacturing, and has the best thermal performance. In situations in which wood is suitable structurally—and as long as it is not harvested from old-growth or sensitive forests—wood is often the best choice.

Regardless of the choice of material, designs that utilize the material most efficiently are better in terms of reducing impacts associated with production. Considerations and opportunities specific to each material are described below.

Structural steel used in construction may come from large integrated mills that make steel from iron ore in a blast furnace or from mini-mills that use electric arc furnaces to make new steel from scrap iron and steel. Many fewer environmental burdens are associated with steel from mini-mills because it is almost 100% recycled and much less energy is used in the manufacturing process. Scrap is also used in integrated mills but at a much lower volume (20–30% of the material).

Steel structures that are bolted together rather than welded will be easier to disassemble in the future, which may allow components to be reused. Because of its high rate of thermal transfer, care should be taken to avoid creating unwanted thermal bridges through a building envelope when using steel.

Concrete consists primarily of large and small mineral aggregates (stone and sand), Portland cement, and water, with various admixtures and (usually) steel reinforcing. Of these components, Portland cement has the most significant environmental burdens by far, chiefly in the form of CO_2 emissions, which contribute to global warming. Producing cement from limestone releases about one ton of CO_2 for each ton of cement. About half of these emissions come from the fossil fuels used to generate heat, and the other half from the limestone itself. As a result, using pozzolanic materials, such as coal fly ash, as a partial substitute for cement in the concrete mix has great environmental benefit. Using coal fly ash also affects many performance parameters of the concrete, generally for the better.

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Source: North American Steel Framing Alliance

Steel framing can protect against insect damage and rot in residential and light-commercial buildings, but care must be taken to avoid excessive heat loss (and heat gain) caused by thermal bridging.

For structural wall systems in small and mid-size buildings, wall form systems that remain in place as part of the wall and provide thermal insulation are an option. These may be made of polystyrene foam, or a cementitious matrix of recycled polystyrene beads or wood fibers. The latter material can be left exposed in industrial buildings and provides excellent sound absorption.

Masonry comes in many different materials and shapes, although cement masonry units (CMUs) are by far the most common. CMUs share many of the same issues as concrete, and CMU buildings often use significant amounts of concrete as grout. As with concrete, coal fly ash may be used instead of some cement in the manufacture of CMUs. CMUs alone are poor thermal insulators, so additional insulation, usually in the form of rigid foam insulation between the CMU wall and a finish surface, is generally required. While such insulation is critical for comfort and reducing energy use, it also adds to the environmental burdens associated with manufacturing the wall system. Autoclaved aerated concrete is a type of masonry block that provides some thermal insulation—about R-1 per inch. Masonry systems do not provide support for floor or roof decks, so they must be coupled with other structural components.

Environmental considerations associated with wood products are covered in *Section 7.1.3*. Solid wood as a structural material is appropriate only for small buildings without large clear spans, as large loads and spans require very large members that are available only from precious, mature trees. For larger spans, engineered wood products, such as glulams and laminated veneer lumber, are viable options. Along with overall environmental impacts, the adhesives used to make these products must also be considered.

References

EBN Archives CD-ROM (contains detailed articles on concrete, wood, and light framing), BuildingGreen, Inc., Brattleboro, VT; (800) 861-0954; www.BuildingGreen.com.

Demkin, Joseph, AIA, ed., *Environmental Resource Guide*, John Wiley & Sons, New York, NY, 1999.

Contacts

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